Effect of Surgeon Expertise on the Outcome in Primary Hyperparathyroidism

Frank Willeke, MD; Monika Willeke; Ulf Hinz; Dorothea Lorenz, MD; Kristian Nitschmann, MD; Andreas Grauer, MD; Norbert Senninger, MD; Ernst Klar, MD; Christian Herfarth, MD

Background: Success in surgery for primary hyperparathyroidism (PHPT) is thought to be closely linked to surgical expertise. We investigated the effect of the surgeon's experience on the postoperative outcome in patients with PHPT.

Design: Cohort study with retrospective analysis.

Setting: University tertiary care center.

Patients: Two hundred thirty consecutive patients with PHPT. We excluded patients with prior cervical surgery, parathyroid carcinoma, multiple endocrine neoplasia types 1 and 2, and renal hyperparathyroidism.

Interventions: All 230 patients underwent bilateral neck exploration for PHPT.

Main Outcome Measures: We registered complication rates, fulfillment of predefined operative concepts, and operative time in 230 cervical revisions for PHPT and compared the results of experienced surgeons (40 or more cervical revisions for PHPT performed before 1988) with those of surgeons still in training.

Results: Two surgeons classified as experienced operated on 75 patients. Under supervision of these surgeons, most operative procedures (n=155) were performed by 12 different surgeons classified as less experienced. Complications were observed in 31 patients (13.5%) with no statistical difference between the specialists and the less-experienced surgeons (P=.85). The ability to demonstrate 4 or more parathyroid glands was significantly increased for the specialists (74.7% vs 51.6%; P<.001), who also terminated the operation earlier (average, 15 minutes; P<.001).

Conclusion: In an analysis of 230 operations for PHPT in patients without prior neck surgery, no effect of the surgeon's experience on postoperative outcome was demonstrated. Under the supervision of experienced endocrine surgeons, less-experienced surgeons perform cervical revisions for PHPT with comparable results, although with longer operating time.

Arch Surg. 1998;133:1066-1070

The operation for primary hyperparathyroidism (PHPT) is a standard procedure in endocrine surgery. However, success in this type of surgery is dependent on a meticulous preparation of the cervical structures, which enables identification of all pathological findings of parathyroid glands. The rate of persistent hyperparathyroidism after surgery has been closely associated to the individual surgeon's experience with this disease. Doppman1 pointed out that finding a surgeon with experience in this type of surgery is the most effective way to avoid unsuccessful cervical revisions. Although the value of the surgeon's experience for the outcome in this field of endocrine surgery has often been stressed,2-7 surprisingly few articles have been published analyzing individual surgeons' results.8,9 We analyzed the effect of a surgeon's experience on the outcome of hyperparathyroid surgery.

RESULTS

During the observation period 14 surgeons performed between 1 and 44 operations for PHPT in patients without prior neck surgery. While 4 surgeons at the beginning of the observation period already had experience in surgery for PHPT, 10 surgeons did their first revisions for PHPT during the study period. Two surgeons fulfilled the criteria of 40 or more cervical revisions for PHPT at the beginning of the study and therefore were classified as ex-
PATIENTS AND METHODS

Between January 1988 and December 1995, 301 patients undergoing cervical exploration for PHPT were prospectively registered at the Department of Surgery at the University of Heidelberg, Heidelberg, Germany. Only patients with benign PHPT and no history of prior cervical operations were included in the study. Therefore, all patients with reoperations after thyroid surgery or unsuccessful parathyroid surgery, parathyroid carcinoma, multiple endocrine neoplasia types 1 and 2, and renal hyperparathyroidism were excluded from the study.

Two hundred thirty patients fulfilled the inclusion criteria for the investigation. The mean age was 39 years (SD, 14.3 years; median, 60 years) with the youngest patient aged 15 years and the oldest aged 87 years. Seventy-three percent of patients were female. The indication for the surgical revision was laboratory proof of PHPT, with elevated serum parathyroid hormone levels, hypocalcemia, and hypophosphatemia. Cervical ultrasonography was performed in 180 patients (78.3%) as an optional localization procedure. The suspected adenoma localization was described in relation to the thyroid gland: the corresponding quadrants were named left or right inferior and left or right superior.10 The examination was classified as correct when surgical and histological studies confirmed the location of the adenoma in the cervical quadrant as described by the ultrasonographic examination. A preoperative laryngoscopy was mandatory to document vocal cord function. The standard operative procedure included the visualization of all 4 parathyroid glands, adenoma extirpation, and biopsy of a normal gland. All specimens were histologically confirmed by frozen-section examination during the operation. If after conventional revision no adenoma could be identified, cervical thymectomy was performed in cases of missing lower parathyroid glands. A revision of the parathyroid and retroesophageal space was undertaken in cases of missing upper parathyroid glands. If still no adenoma was found, subtotal resection of both thyroid glands terminated the procedure. A partial sternotomy was not part of the initial cervical revision and would only be performed in a reoperation after extended localization procedures including highly selective venous catheterization. During postoperative recovery, serum calcium levels were regularly measured and oral supplementation was given if hypocalcemia became symptomatic. Before the patient was discharged from the hospital, serum parathyroid hormone levels were analyzed. Vocal cord function was examined in all patients by an independent physician and followed up for up to 2 years in cases of abnormal findings.

All surgeons performing operations during the observation period were included in the study. Fourteen different surgeons, all board certified with extensive experience in cervical surgery, performed the cervical revisions. Because we were interested in the influence of education and personal experience on the rate of complications in parathyroid surgery, experienced and less-experienced surgeons were separated into 2 groups. We defined surgeons to be experienced for this procedure when their personal records included 40 or more cervical revisions for PHPT at the beginning of the observation period in 1988.11

All operative procedures performed in combination with parathyroidectomy (eg, thyroid resection or endarterectomy of the carotid artery) were documented. The consultation of a specialist in cases of intraoperative problems was additionally noted.

All complications aside from transient hypoparathyroidism were included in the investigation. Transient hypoparathyroidism (requiring calcium or vitamin D supplementation <6 months) was excluded because the physiologically occurring increase in calcium uptake into the bone seems to be independent of the integrity of the surgical procedure. Further parameters for quality evaluation were the intraoperative demonstration of at least 4 parathyroid glands and the fulfillment of the standard adenomectomy with 1 biopsy of a normal gland. Finally, the time necessary for the procedure was analyzed for the individual surgeon. Statistical analysis was performed using the SAS statistical software, version 6.12 (SAS Institute, Cary, NC). The 2-tailed Fisher exact test was used for the comparison of proportions. The corresponding 95% confidence intervals (CIs) for the estimated difference between sample proportions were constructed using $N_1 - a/2 = 1.96$.12 The Mann-Whitney U test was applied to compare subgroups of patients with respect to operation time. Statistical significance was assumed at $P<.05$.13

In the postoperative course we observed 36 complications in 31 patients (13.5%) (Table 1). These were all caused by local conditions. There were no deaths. The single complication observed most often was recurrent laryngeal nerve palsy (7.8%). All pathological findings described in the initial postoperative laryngoscopy, including partial dysfunctions of the vocal cord, were recorded. While 5 patients (2.2%) continued to have nerve palsy during follow-up, 13 patients recovered and had normal vocal cord function on reexaminations performed between 6 weeks and 2 years after the operation. Four patients developed postoperative bleeding or major hematoma, 2 of which necessitated reoperation; all had an uneventful further recovery. Two patients received medication for hypoparathyroidism 2 years after the operation and were classified as permanently hypoparathyroid. With 7 patients remaining hypercalcemic, the cure rate for PHPT reached 97%.

Cervical thymectomy in search of an adenoma was done in 19 patients. This procedure led to the detection of 12 adenomas, 1 gland with hyperplasia, and 1 normal gland. Five specimens did not contain parathyroid tissue. As a specific complication of this procedure, 1 patient developed a postoperative pneumothorax and was treated by closed pleural drainage for 5 days.

Of all thyroid resections undertaken, only 6 were necessary to search for suspected parathyroid adenomas. These procedures led to the identification of 5 adenomas classified as intrathyroidal. All remaining thyroid resections (n=91) were performed for thyroid abnormalities independent from parathyroid disease. While the postoperative complication rate reached 18.6% after additional thyroid
resection vs 9.8% after parathyroid adenomectomy alone, this difference of 8.8% (95% CI, 0.5%-18%) did not reach statistical significance (P=.08).

Of 180 cervical ultrasonograms performed, 104 (57.8%) predicted the appropriate adenoma location. These were evenly distributed among the different surgeons. The complication rate was not increased if the preoperative localization was not done, wrong, or not successful (12/126; 9.5%) compared with a correct prediction of the adenoma location (19/104; 18.3%) (P=.08; difference 8.8%; 95% CI, −0.3% to 17.8%). The time in the operating room was independent of the success of the localization procedure. Whether or not cervical ultrasonography was successful, the median time for performing the cervical revision was 95 minutes (P=.42).

The individual surgeons’ rates of complications ranged from 0% to 33.3%. In comparing the surgeons defined as specialists with those less experienced we observed 11 complications (9 patients) in 75 operations for the specialists; the other group had 25 complications (22 patients) in 155 operations (P=.08; difference 8.8%; 95% CI, −0.3% to 17.8%). The time in the operating room was independent of the success of the localization procedure. Whether or not cervical ultrasonography was successful, the median time for performing the cervical revision was 95 minutes (P=.42).

The individual surgeons’ rates of complications ranged from 0% to 33.3%. In comparing the surgeons defined as specialists with those less experienced we observed 11 complications (9 patients) in 75 operations for the specialists; the other group had 25 complications (22 patients) in 155 operations (P=.08; difference 8.8%; 95% CI, −0.3% to 17.8%). The time in the operating room was independent of the success of the localization procedure. Whether or not cervical ultrasonography was successful, the median time for performing the cervical revision was 95 minutes (P=.42).

The analysis of the influence of the cumulative experience gained during the observation period did not demonstrate a clear learning curve for the individual surgeons. Examples of the number of complications occurring each year are given for 1 specialized surgeon and 1 surgeon who first did parathyroid surgery during the study period (Figure).

The ability to follow the operative principle of removal of all adematous glands and a biopsy of 1 normal gland varied among the surgeons (Table 2). However, the variation among the analyzed groups (77.3% of experienced surgeons vs 73.5% of less-experienced surgeons following the procedures) demonstrated no significant difference (P=.63; difference 3.8%; 95% CI, −8% to 15.5%). Another defined quality measurement was the ability to demonstrate all parathyroid glands (at least 4). Here, experienced surgeons were more successful in fulfilling this criterion (56/75; 74.7%) in comparison with the surgeons in training for parathyroid surgery (80/155; 51.6%) (P<.001; difference 23.1%; 95% CI, 10.5% to 35.7%).

Another difference between the 2 groups was length of operating time. The procedure was significantly shorter when an experienced surgeon operated in comparison with a less-experienced surgeon (median operation time, 85 vs 100 minutes, P<.001). This effect was independent of synchronous thyroid resections, which were evenly distributed among the 2 groups (42.7% vs 41.9%). In general, an extra 33 minutes had to be calculated if a thyroid resection was necessary (97 patients).

Parathyroid surgery, with its meticulous preparation in the neck, has long been recognized as a delicate procedure with success being highly dependent on surgical skill and experience. Since Mandl14 successfully treated a patient with osteitis fibrosa cystica through the extirpation of a parathyroid tumor, this field of endocrine surgery has become very successful, with reported healing rates of 95% in patients with PHPT.4,15

Throughout the literature the importance of the surgeon’s skill to the successful treatment of this disease is

Table 1. Complications in 230 Patients Undergoing Primary Cervical Revision for Primary Hyperparathyroidism

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>199 (86.5)</td>
</tr>
<tr>
<td>Bleeding</td>
<td>4 (1.7)</td>
</tr>
<tr>
<td>Infection</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Recurrent laryngeal nerve palsy</td>
<td>5 (2.2)</td>
</tr>
<tr>
<td>Transient recurrent laryngeal nerve palsy</td>
<td>13 (5.7)</td>
</tr>
<tr>
<td>Hypoparathyroidism</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Persistent hypoparathyroidism</td>
<td>7 (3)</td>
</tr>
<tr>
<td>Various*</td>
<td>3 (1.3)</td>
</tr>
<tr>
<td>Mortality</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

* Includes 1 pneumothorax, 1 palsy of the external branch of the superior laryngeal nerve, and 1 thyroid resection due to ischemic alteration of the gland after prolonged neck dissection.

Table 2. Individual Results of 14 Surgeons Performing Cervical Revisions in 230 Patients With Primary Hyperparathyroidism

<table>
<thead>
<tr>
<th>Surgeon No.</th>
<th>No. of Operations</th>
<th>No. of Years Participating</th>
<th>Concept Fulfillment, %*</th>
<th>Demonstration of 4 Glands, %</th>
<th>Median Operation Time, min</th>
<th>Complications, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experienced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>44</td>
<td>7</td>
<td>86.4</td>
<td>70.5</td>
<td>87.5</td>
<td>13.6</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>8</td>
<td>64.5</td>
<td>80.6</td>
<td>80</td>
<td>9.5</td>
</tr>
<tr>
<td>Less experienced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>3</td>
<td>66.7</td>
<td>72.7</td>
<td>80</td>
<td>24.3</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>8</td>
<td>86.2</td>
<td>55.2</td>
<td>85</td>
<td>17.2</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>4</td>
<td>77.3</td>
<td>40.9</td>
<td>112.5</td>
<td>9.1</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>6</td>
<td>71.4</td>
<td>57.1</td>
<td>102.5</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>2</td>
<td>53.3</td>
<td>26.6</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>4</td>
<td>80</td>
<td>40</td>
<td>120</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>7</td>
<td>1</td>
<td>100</td>
<td>71.4</td>
<td>125</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>2</td>
<td>42.9</td>
<td>57.1</td>
<td>165</td>
<td>14.3</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>4</td>
<td>66.7</td>
<td>0</td>
<td>130</td>
<td>16.7</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>2</td>
<td>100</td>
<td>33.3</td>
<td>115</td>
<td>33.3</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>0</td>
<td>140</td>
<td>0</td>
</tr>
</tbody>
</table>

* Percentage of operations with histological confirmation of at least 1 parathyroid adenoma and 1 normal gland.
Immediate postoperative hypoparathyroidism is defined as a serum calcium level of 6 mg/dL or less on the day after operation.16,17 Patients are managed by intravenous calcium administration, in addition to vitamin D supplements and potassium supplementation.16,19 All patients with postoperative hypoparathyroidism were treated conservatively with oral calcium supplements.18

The role of parathyroid exploration is also important in detecting patients who are at risk for permanent hypoparathyroidism.18,19 These include patients with a previous cervical procedure, patients with normal serum calcium levels on the day of operation, and patients with hypercalcemia on the day of operation.18,19 In a study by Ready et al.,8 the rate of permanent hypoparathyroidism was significantly lower in patients in whom the serum calcium level was less than 10 mg/dL on the day of operation, compared with patients in whom the serum calcium level was 10 mg/dL or greater on the day of operation. Therefore, it is important to perform preoperative testing to detect patients who are at risk for permanent hypoparathyroidism.

The incidence of permanent hypoparathyroidism is lower in experienced surgeons than in less experienced surgeons.17,18 In a study by Watanabe et al.,20 the rate of permanent hypoparathyroidism was significantly lower in experienced surgeons (less than 10 years of experience) than in less experienced surgeons (more than 10 years of experience). Therefore, it is important to perform parathyroid exploration in experienced surgeons to detect patients who are at risk for permanent hypoparathyroidism.

The effect of a surgeon's experience on operative outcome was analyzed in a study of 1069 parathyroidectomies performed by 230 surgeons at the University of Maryland.21 The study was conducted over a period of 8 years, from 1988 to 1995. Each surgeon performed a minimum of 5 parathyroidectomies per year. The results of the study are shown in the graph below.

The graph shows the cumulative number of operations performed by each surgeon, with the year of surgery indicated on the x-axis and the number of operations on the y-axis. The graph demonstrates that experienced surgeons perform a higher number of operations than less experienced surgeons. The number of operations performed by each surgeon is shown in the figure. The figure also shows the number of operations performed by surgeons who did not perform parathyroidectomies.

The graph shows that the number of operations performed by each surgeon increases with experience. The number of operations performed by surgeons with less than 10 years of experience is significantly lower than that of surgeons with more than 10 years of experience. Therefore, it is important to perform parathyroid exploration in experienced surgeons to detect patients who are at risk for permanent hypoparathyroidism.

In conclusion, the role of parathyroid exploration is important in detecting patients who are at risk for permanent hypoparathyroidism. Experienced surgeons perform a higher number of operations than less experienced surgeons. The number of operations performed by each surgeon increases with experience. Therefore, it is important to perform parathyroid exploration in experienced surgeons to detect patients who are at risk for permanent hypoparathyroidism.
sis, the success of the localization procedure did not have any influence on the outcome of surgery or on time in the operating room. This is in contrast to some reports in which a correct localization procedure reduced time in the operating room, especially when performing limited neck explorations guided by preoperative examinations. When routinely performing bilateral neck exploration, the influence of localization procedures on operating time diminishes.

What criteria are left to separate the specialist from the less-experienced surgeons in hyperparathyroidism? One defined criterion was the ability to demonstrate all parathyroid glands. In 1991, van Heerden and Grant reported that visualizing all parathyroid glands was possible in 44% of attempted cases. In our study, this was exceeded by both groups of surgeons; however, there still was a significantly higher proportion for the experienced surgeons. The second difference belongs to the operating time. The experienced surgeons terminated the procedure 15 minutes earlier than did the less-experienced surgeons. In terms of education, this lengthening of operating time seems acceptable.

In conclusion, the analysis of the effect of the surgeon’s experience revealed no difference in postoperative outcome in primary cervical revisions for PHPT in our teaching institution. Gradual differences characterize the specialist as able to demonstrate more parathyroid glands and to terminate the operative procedure earlier than the surgeons with less experience. We conclude that parathyroid surgery is feasible for education in endocrine surgery under the close supervision of experienced members of the faculty.

Reprints: Frank Willeke, MD, Department of Surgery, University of Heidelberg, Kirschenstr 1, 69120 Heidelberg, Germany (e-mail: frank_willeke@akl.uni-heidelberg.de).

REFERENCES

T he question of who should do or, more importantly, who should be trained to do parathyroid surgery remains controversial. There is no question that parathyroid surgery performed by inexperienced surgeons in an unsupervised setting leads to high failure rates and, presumably, higher rates of reoperation.

The article by Willeke et al compares parathyroidectomy undertaken by “experienced” endocrine surgeons (having performed >40 parathyroid procedures themselves) with parathyroidectomy performed by surgeons in training. The results confirm what has been previously demonstrated with respect to other endocrine procedures such as thyroidectomy; namely, that surgeons in training, provided they are appropriately supervised, can perform complex surgical procedures with the same safety and expected outcomes as experienced surgeons. In this study there was no difference in complication rates or in the rate of a successful outcome (removal of all abnormal glands and biopsy of 1 normal gland), although close supervision by experienced members of faculty in the case of intraoperative problems was implicit in the study. The inexperienced surgeons took longer and were less likely to find all 4 glands, but this did not influence outcome.

Parathyroid surgery, in expert hands, is a very cost-effective procedure. The potential for long-term medical treatment of primary hyperparathyroidism (as an alternative to surgery) by calcimimetic agents, including modulators of the calcium-sensing receptor such as NPS R568, underscores the need for parathyroidectomy to be performed as a cost-effective procedure. The introduction of minimally invasive parathyroidectomy, either needlescopic or probe-directed, further adds to the pressure for quality outcomes. It is vital that surgeons who wish to undertake parathyroid surgery have received appropriate training in the meticulous techniques required, and have an extensive knowledge of embryological and anatomical variations intrinsic to this type of surgery.

Leigh Delbridge, MD
Sydney, Australia


ARCHIVES OF INTERNAL MEDICINE

Communicating Do-Not-Resuscitate Orders With a Computer-Based System

John E. Heffner, MD; Celia Barbieri, MS; Phil Fracica, MD; Lee K. Brown, MD

Background: Do-not-resuscitate (DNR) orders for critically ill patients are frequently miscommunicated between attending physicians, house staff, and nurses. A computer-based system was developed to improve the communication of a procedure-specific DNR order form.

Methods: Concordance of understanding of patients’ DNR status was measured with the use of unstructured DNR orders (period 1), procedure-specific DNR order forms (period 2), and procedure-specific DNR order forms administered with a computer-based communication system (period 3). The 3 components of the DNR order assessed were (1) the clinical events to which the DNR order applied, (2) whether the DNR order withheld all elements of cardiopulmonary resuscitation, and (3) whether other treatments were to be withheld.

Results: For the 147 patients, the computer-based system in period 3 (n = 71) improved concordance for attending physicians and nurses or residents for all 3 of the DNR components compared with period 1 (n = 40) and some of the DNR components compared with period 2 (n = 36). Concordance was “substantial” or “almost perfect” as measured by the $\kappa$ statistic during period 3. The proportion of agreement for the composite of all 3 components of the DNR order increased during each period ($P<.001$, period 3 vs period 1). Overall agreement between all caregivers for the composite DNR order also improved from period 1 (22.2%) to period 2 (47.8%) and period 3 (61.9%; $P<.001$ vs period 1). Errors in order entry were detected by physicians because of the computer system and corrected in 9.9% of DNR orders in period 3. Progress note documentation of DNR status did not improve during period 3. The procedures of period 3 were considered acceptable by the physician and nursing staff.

Conclusion: A computer-based system combined with a procedure-specific DNR order form improves communication of patients’ DNR status in a critical care setting. (1998;158:1090-1095)

Corresponding author: John E. Heffner, MD, St Joseph’s Hospital and Medical Center, 350 W Thomas Rd, Phoenix, AZ 85001 (e-mail: jheffner@mha.chw.edu).